to .1, and of real refractive index varying from 1.44 to 1.55. For the higher values of the extinction coefficient, the total scattering coefficient may be in error by 1%. When the extinction coefficient is zero, approximate values of the scattering coefficient will be obtained for transparent materials of refractive index as low as 1.33 and as high as 1.65 by substituting into the polynominal expression for $K(m; \alpha)$.

The number concentration, n, or the particle size, can be obtained when either is known by measuring the transmission at a known wavelength; or both can be obtained by measuring the transmission at two or more wavelengths. The transmission, $T = e^{-K\pi r^2 nl}$, where $K\pi r^2 n$ is the "absorption" coefficient as usually defined, i.e., $e^{-K\pi r^2 nl}$ is the fraction of light scattered by transparent particles or scattered and absorbed by absorbing particles per unit distance in the suspension.

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MECHANICAL AIDS TO COMPUTATION

See also the two introductory articles of this issue, as well as RMT 305.

22. DE FOREST ON ELECTRICAL COMPUTERS.—To the *Yale Scientific Monthly*, published by the Senior class of the Sheffield Scientific School, Yale University, LEE DE FOREST (1873–) contributed an article ("A Wheatstone bridge for solving numerical equations," v. 3, 1897, p. 200–206),[1] explaining an idea of his for the electrical solution of equations. After describing a scheme in which the operator achieved his solution by adjusting the sliders on resistance potentiometers so as to balance a Wheatstone bridge, he pointed to the possibility of an "automatic balancer." He believed that "a relay type galvanometer driving or reversing some electrically governed mechanism might be devised, which would keep this length shifting until balance was attained."

If not the first, this is at least a very early description of the self-centering servomechanism as a computing device, the basic unit of some of the most important military computers of the recent war, including the electrical gun director for the control of anti-aircraft fire.

DeForest may be pardoned for his qualifying remark—"it could not be very accurately done"—since, presumably, he did not yet know that he was going to invent the three-element thermionic valve, which did so much to make high precision possible.

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[1] EDITORIAL NOTE: This machine is one which escaped the attention of J. S. FRAME in his survey article "Machines for solving algebraic equations," *MTAC*, v. 1, p. 337–353. He did, however, deal with the machines of G. B. GRANT, C. V. BOYS, L. L. C. LALANNE referred to by DeForest in his introductory paragraphs. DeForest adds the new remark, that A. W. PHILLIPS (1844–1915) of Yale University was in 1879 an independent inventor of Lalanne's machine. Phillips was dean of the Graduate School 1895–1911, and the joint author of a number of texts in elementary mathematics.

NOTES

56. APPROXIMATIONS TO π.—In R. So. London, *Trans.*, 1841, p. 281–283, WILLIAM RUTHERFORD (1798?–1871) gave a value of π to 208D, which was correct to 152D, and derived from the Euler formula (1764)

$$(1) \qquad \frac{\pi}{4} = 4\tan^{-1}\frac{1}{5} - \tan^{-1}\frac{1}{70} + \tan^{-1}\frac{1}{99}.$$